

# Effect of Organic Amendments on Lemon Leaf Tissue, Soil Analysis and Yield<sup>1</sup>

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## *Abstract*

*An experiment was initiated in 2000 to study the feasibility of growing organic lemons in the southwest desert of Arizona. An eight-acre field was selected on Superstition sandy soil at the Mesa Agricultural Research Center to conduct this investigation. Lemon trees were planted at 25 x 25 feet spacing in 1998. The initial soil test in top 6 inches was 5 ppm nitrate-nitrogen and 4.9 ppm NaHCO<sub>3</sub>-P. Soil pH was 8.7 in the top 6 inches. Four treatments were applied in randomized complete block design repeated four times. The treatments were beef cattle feedlot manure and perfecta, clover and guano from 2000 to 2002, cowpea and guano in 2003, and guano and perfecta, and standard practice treatment. Soil samples were collected from 0-6 and 6-12 inches the first week of March 2003 and analyzed for available nutrients. Results showed a difference for most nutrients in 0 to 6 and 6 to 12 inches between treatments. Nitrate- nitrogen increased significantly from 3.25 ppm in standard treatment to 19.10 ppm in the manure treatment. Similarly, soil organic matter increased from 0.1% in standard treatment to 0.2% in the manure perfecta treatment. Phosphorus level increased significantly from 7 ppm in guano perfecta to 56.5 ppm in manure perfecta treatment. Leaf tissue analysis indicated that nitrate level was influenced by treatment. Both commercial standard and organic treatments were equally effective in controlling citrus thrips, but repeated applications were required. Mite population has been detected at low level with no significant differences observed among treatments.*

## **Introduction**

Total lemon acreage in Arizona is about 13,000 acres down 2,000 acres from 1993 (Arizona Agricultural Statistics 2000). Among the 13,000 acres in the state about 12,000 acres of lemon are grown in Yuma. Yield fluctuates from year to year with an average yield of 550 cartons per acre. There is an increasing demand for organically grown citrus among consumers. Some states are already responding to consumer's demand by growing organically some of the citrus acreage. There is also a need for evaluating the possibility of growing lemon organically in Arizona.

Manure as a source of organic nutrients is available from the existence of a feedlot and two dairy farms in Yuma County. However, there is complex problem associated with organically grown lemon. Weeds and pest control are the most critical challenges facing organically grown citrus. The objective of this project was to evaluate the feasibility of growing organic lemon in Yuma.

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<sup>1</sup> The authors wish to thank the Arizona Citrus Research Council for their financial support of this project. This is the final report for project 2002-10 'Organic lemon production'.

In Arizona, citrus thrips, *Scirtothrips citri* is the primary insect pest that acts as a hindrance to organic citrus production. Traditionally, non-organic broad-spectrum insecticides have been used to control citrus thrips. In 1999 a particle film became available, Surround WP, that was shown to have activity towards citrus thrips. Surround is a highly refined kaolin mineral that produces a white coating on the tree, but does not interfere with photosynthesis or stomatal conductance. This coating acts as a repellent, and clings to thrips that come into contact with it, resulting in some mortality. In addition to thrips control and sunburn protection, Surround has been shown to increase fruit earliness and may increase yield in mature citrus. In 2000, Surround was approved by OMRI as an organic pesticide.

## Materials and Methods

An experimental site was selected on Superstition sand soil at the Yuma Mesa Agricultural Research Center, University of Arizona to evaluate the effect of organic amendments, weed and insect control on lemon growth and yield. Selected soil chemical properties (Table 1) indicated high pH at 8.7, low nitrate nitrogen level of 2.9 ppm and low potassium level at 59 ppm in the top 6-inches soil. Lemon trees were planted in 1998, twelve trees per row in east west orientation at 25 x 25 feet spacing. Each experimental unit was made of two-twelve tree rows with one-twelve tree row used as a guard row. All plots were flood irrigated once a week or every other week depending on the season. Since 2000, the experimental layout had four treatments including standard practices, manure perfecta, clover and guano perfecta, applied in completely randomized block design replicated four times. Manure was applied at 10 tons per acre with a manure spreader in March 2003. Guano was applied as guano 7-7-7 N-P-K with irrigation water to provide 40-lb N, 40-lb P and 40-lb K per acre. Standard practices treatments included an application of nitrogen as ammonium sulfate and, phosphorus as 11-52-0 (N-P-K). Beginning in 2000, nitrogen in the standard treatments was applied using UN 32-00 as the source at a rate of 2.5 units per acre.

In 2003 cowpea replaced clover as an alternative cover crop, was planted in late January, 2003. We anticipated that the cowpea would out compete and control weeds in the cowpea treatment better than clover did in previous years. Weeds in the standard treatment were controlled by a repeated disking and roundup application. In the manure and guano treatments we used a Perfecta field cultivator to control weeds.

Following manure, guano and fertilizer applications in the standard treatments, soil samples were taken from 0-6 and 6-12 inch deep beginning on April 12, 2001, then periodically thereafter and analyzed in a commercial laboratory.

Thirty leaves were randomly collected in zip lock bags and brought to the laboratory. Leaves were washed with distilled water, and divided in two groups. The first sample group was ground with a small food processor. Nitrate-nitrogen determination was made immediately using portable electrode, Cardy meter. The second half was oven dried at 65 C, ground to pass one mm screen and sent to a commercial laboratory for chemical determination.

Insect control treatments were divided into two regimes, organic and a commercial standard. The organic regime was subdivided into three treatments based on fertilizer, ground cover, and weed management. All organic treatments were composed of only OMRI approved materials and subject to change depending on the pest encountered. In 2001, citrus thrips, *Scirtothrips citri* and Yuma Spider Mites were encountered, but citrus thrips was the only pest at economically damaging levels. Thus, the organic treatment consisted only of applications of Surround WP (kaolin) applied at 50 lbs/ac. The commercial standard consisted of applications of either Dimethoate at 2 lbs-ai/ac, Success (spinosad) at 4 oz/ac, or Carzol (formetamate HCL) at 1 lb/ac. Surround treatments were applied 3 to 4 times annually in the spring, depending on coverage of the fruit. Standard treatments were applied on an as-needed basis depending on thrips populations. Additional Surround applications were made up to two times during the summer to counter sunburn. All treatments were applied using a hand-gun sprayer calibrated to deliver 250 gal/ac.

Citrus thrips and mite populations were sampled using an 8 x 12 in. black baking pan covered by 0.25 in. hardware cloth. Yellow 3 x 5 in. sticky cards were placed in the bottom of the pans to capture the pests. Samples were taken from flush growth by tapping the growth onto the hardware cloth for 5 sec. Forty pieces of flush were sampled per treatment replicate. Four pieces of flush were sampled per sticky card. The sticky cards were transported to the

laboratory where adult and immature thrips and mites were counted under a dissecting scope. Treatment differences were discerned using ANOVA and an F protected LSD ( $P < 0.05$ ).

Damage ratings, using a 1 to 5 scale, were taken on in the fall by visually rating damage to the foliage that was produce between April and October. The rating scale used was 1 = no damage, 2 = few crinkled leaves present, 3 = many crinkled leaves present, 4 = many crinkled leaves and some defoliation present, and 5 = substantial defoliation present (buggy whipping). Treatment differences were discerned using ANOVA and an F protected LSD ( $P < 0.05$ ).

Yield data is collected during the fall and winter. For 2001-02, yield data was collected on 2/7/02, and the average weight per tree was less than 1.0 lb per tree, thus that data is not presented here. For 2002-03, the entire yield of the treated row was harvested and was passed through an automated electronic eye sorter (Autoline, Inc., Reedley, CA), which provides weight, color, exterior quality and size data for each fruit. Fruit packout data is reported on a percentage basis. Fruit quality data was collected at each harvest time. These data include °brix, peel thickness, percentage juice, pH, and total soluble solids to total acid ratio. There was no effect of rootstock on fruit quality (data not shown).

## **Results**

### Soil Chemical properties

Initial selected soil properties are reported in table 1. Soil organic matter and nitrogen were low, and pH was high. In 2003, soil was sampled from 0-6 and 6-12 inch deep and analyzed in commercial laboratory. The results showed a significant amendment by depth interaction (Table 2) only for organic matter (OM) and phosphorus. Significant differences were observed among treatments. The application of various amendments significantly influenced most of soil nutrients except Na, Ca, CEC and Mn (Table 2). Phosphorus, nitrate nitrogen, pH and organic matter in the top 6 inches of soil were significantly affected by manure treatment. Phosphorus increased from 10 ppm in guano treatment to 56.50 in manure while nitrate increased from 3.25 ppm in standard treatment to 19.0 ppm in manure treatment which also lowered pH to 8.2 from 8.7 in the initial soil characterization. Similar results were obtained in 12 inch top soil (Figure 1)

Repeated manure applications of manure from 2000 to 2003 resulted in significant phosphorus build up in manure treatment (Figure 1). This soil P level is considered as high according to University of Arizona recommendations and probably reaches the point where crops are unlikely to respond to any P fertilizer application.

### Leaf samples

In 2003, 30 leaf samples were collected, washed with distilled water. One half of samples were dried at 60C and ground to pass 1 mm sieve before they were sent to a commercial laboratory. The other half was ground with food processor and leaf nitrate-nitrogen was determined by Cardy meter. Although the results present some variability, manure appears to have a greater effect on sap nitrate during the July's sampling (Figure 2).

### Yield

Lemon yield data collected in 2003 are reported in Figure 3. The highest yield is recorded from manure and cow pea treatment amendments. However data show that the standard practices using fertilizer and manure treatment had similar effect on yield (pounds / tree). Guano and cowpea had a similar effect on yield but both were significantly lower than manure and standard cultural practices. Fruit sizes were separated into 8 categories for each treatment. There is no significant of treatment effect on fruit size.

### Insect control

Both the commercial standard and the organic treatment regimes were equally effective in controlling citrus thrips (Figure 4). All of the treatment regimes required multiple applications to maintain control due to the continual production of fresh unprotected flush. Mite populations, although detectable, were not high and we could not detect any differences among the treatments for mite control (Figure 5). The fact that the mite populations did not develop to economically threatening level in any of the treatments indicates that these treatments may have some mite

activity. However, since our experimental design did not utilize an untreated control, this possibility cannot be verified without further investigation.

Based on damage ratings, the organic regimes and the commercial standard were equally effective in preventing substantial damage (Figure 6). A mean damage rating above 3 would indicate a failure to effectively prevent significant damage.

Table 1. The initial soil characterization taken at different depths.

Soil depth, in.	PH	Salinity dS/M	Sodium ppm	Nitrate ppm	Phosphorus ppm	Potassium ppm	Calcium ppm
0-6	8.7	0.5	50	2.9	4.9	59	4800
6-12	8.9	0.5	86	4.2	6.1	64	4700
12-24	8.6	0.5	57	4.3	4.5	60	4200
24-36	8.5	0.5	58	2	3.2	62	5600
36-48	8.7	0.5	56	1.6	2.3	56	5800

Table 2. Analysis of variance showing the level of significance among treatment applied to organic lemon experiment, depth of sampling and depth \* treatment interaction, Yuma Mesa Agricultural Experimental Station, 2003.

Source of variation	pH	Salt	OM	NO <sub>3</sub>	P	K	Ca	Mg	Na	S	Zn	Fe	Mn	B	CEC
	unit		%	----- ppm -----											meq/100 g
Replication	0083	0047	.NS	NS	NS	NS		NS	NS	NS	0.053	0.002	NS	0.058	0.0121
Treatment (T)	0.023	0.025	0.006	0.008	0.000	0.004	NS	NS	NS	0.016	0.000	0.002	NS	0.058	NS
Depth (D)	0.016	0.054	0.086	0.021	0.000	0.013	NS	0.016	NS	0.019	0.001	0.017	0.090	NS	NS
T*D	NS	NS	0.004	0.026	0.000	0.082	NS	NS	NS	NS	0.000	0.016	NS	NS	0.0100
CV	1.19	12.33	28.57	53.14	17.10	27.20	2.57	8.28	14.0	17.81	25.84	8.84	54.27	28.52	2.57
Means	8.61	0.298	0.175	5.53	15.62	90.68	2503	201.6	67.9	4.62	0.865	2.69	0.375	0.277	14.73
R <sup>2</sup>	0.912	0.864	0.939	0.899	0.988	0.872	0.687	0.759	0.446	0.850	0.973	0.916	0.707	0.595	0.665

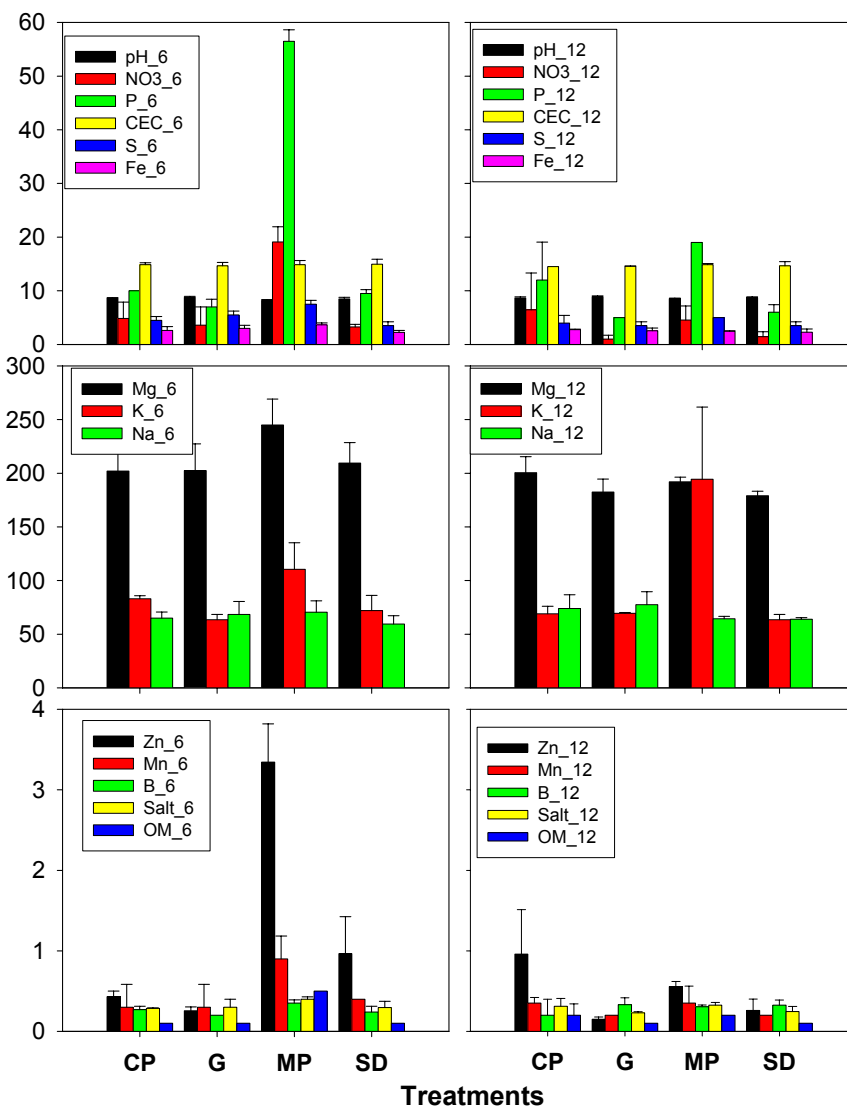


Figure 1 Soil chemical properties at 6 in (left) and 12 inch (right) as affected by cowpea (cp), Guano perfecta (G), manure perfecta (MP) and Standard fertilizer practices (SD) treatment, Yuma Mesa Agricultural Research Center, 2003.

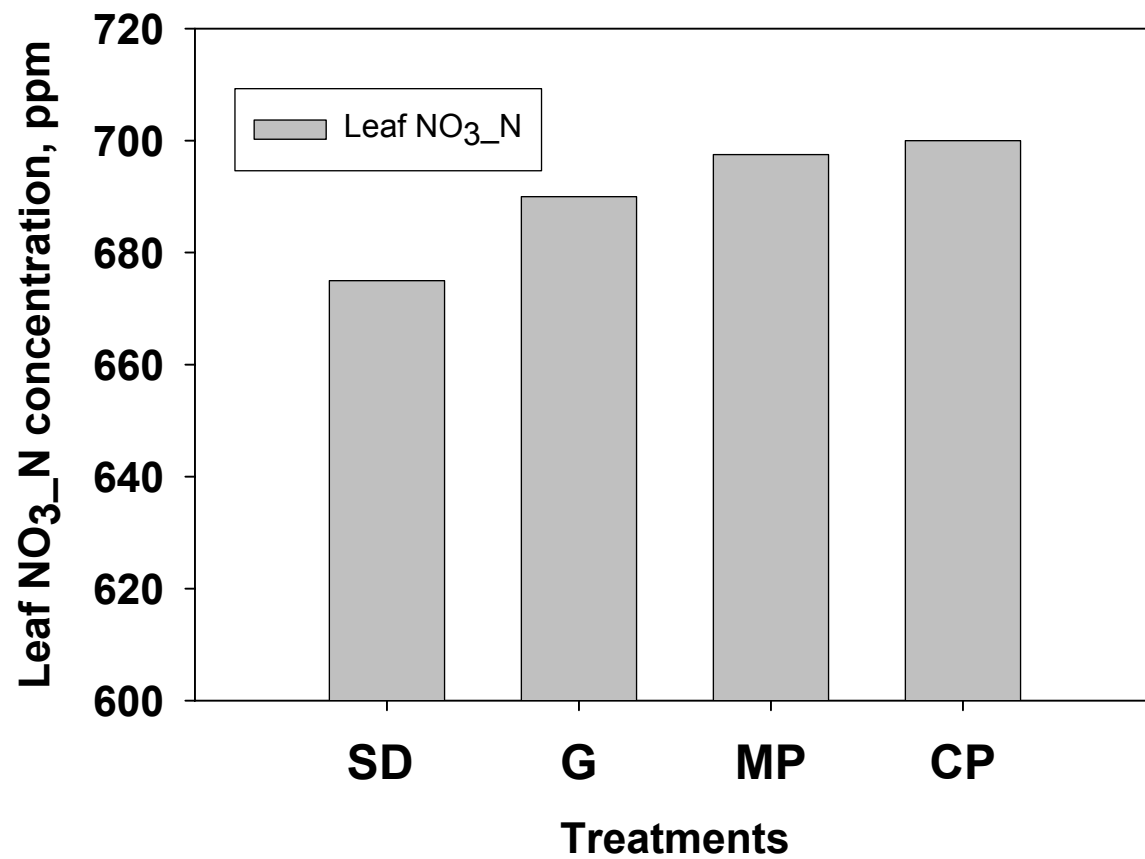


Figure 2 Leaf Nitrate nitrogen sampled in July 2003. Treatments include standard fertilizer (SD), Guano perfecta (G), manure perfecta (MP) and cow pea (CP) Yuma Mesa Agricultural Experimental Station, 2003

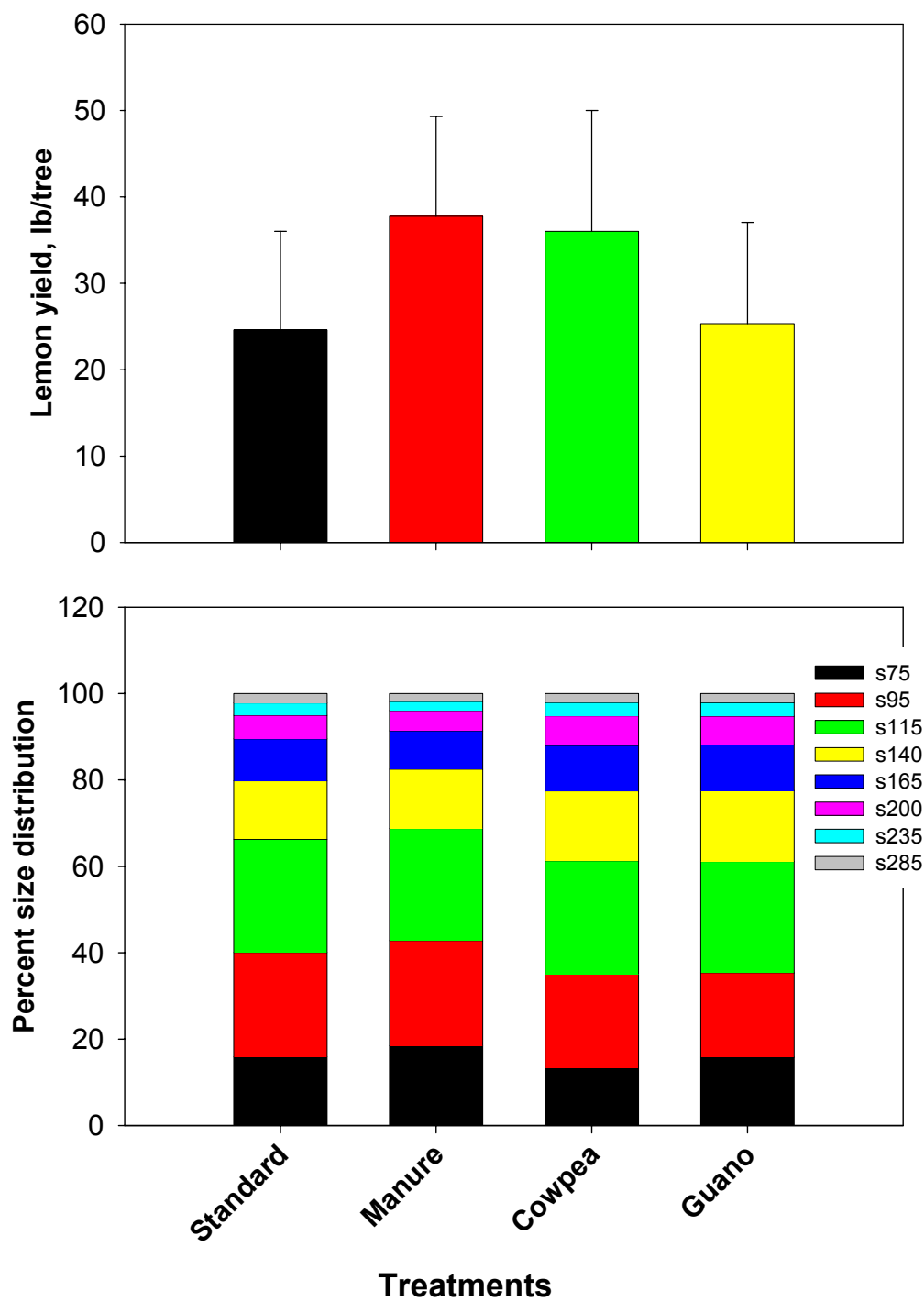


Figure 3. Lemon yield (top) and size distribution as affected by organic amendments and standard fertilizer practices at Yuma Mesa Research Station, Yuma 2003.

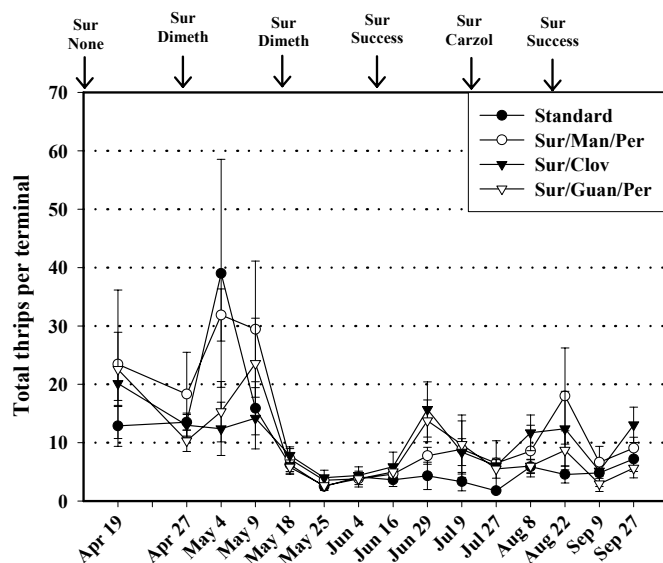


Figure 4 **Mean** number  $\pm$  SEM of citrus thrips per terminal flush on lemons treated organically or with commercial standard insecticides. The organic treatments were all treated with Surround but consisted of different fertilizer, ground cover, and weed management programs.

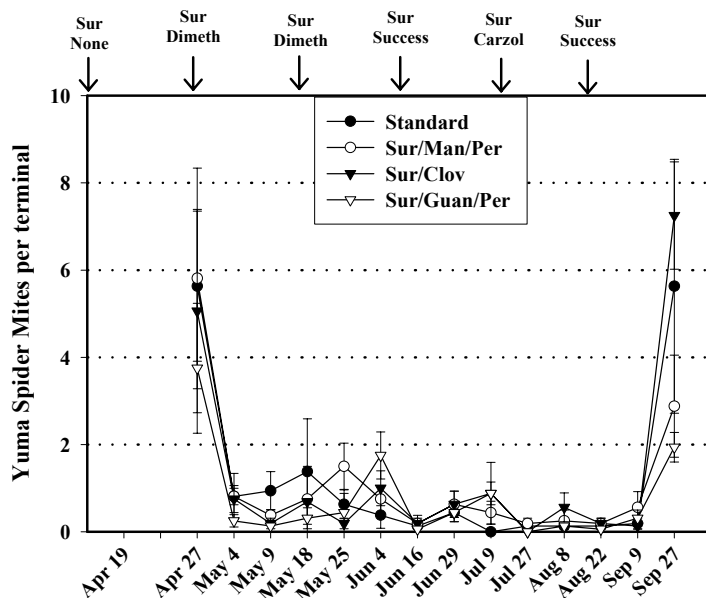


Figure 5 **Mean** number  $\pm$  SEM of Yuma spider mites per terminal flush on lemons treated organically or with commercial standard insecticides. The organic treatments were all treated with Surround but consisted of different fertilizer, ground cover, and weed management programs.



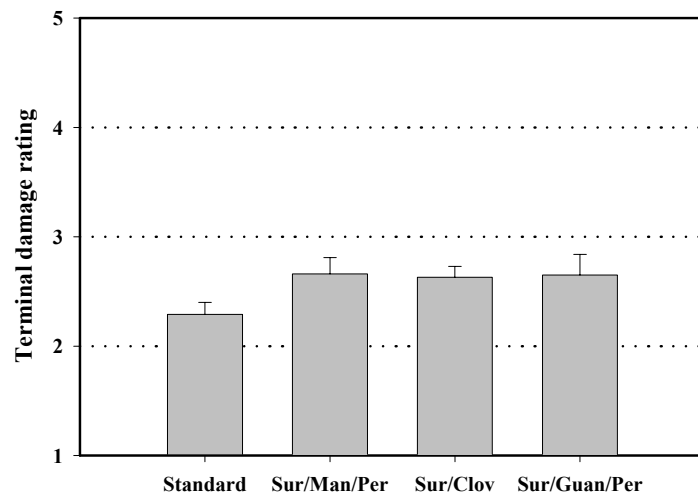


Figure 6 **Mean** number  $\pm$  SEM damage rating of lemon terminal growth treated organically or with commercially standard insecticides. The rating scale was 1 = no damage, 2 = few crinkled leaves present, 3 = many crinkled leaves present, 4 = many crinkled leaves and some defoliation present, and 5 = substantial defoliation present (buggy whipping).